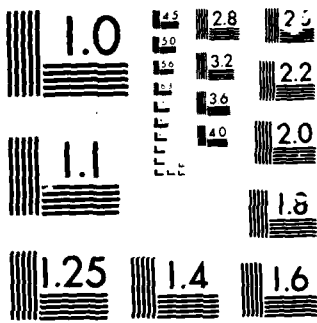


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DESIGN, FABRICATE AND TEST SPACECRAFT AUTOMATIC
ACTIVE DISCHARGE SYSTEM (SAADS)

Robert S. Hills

TRI-CON ASSOCIATES, INC.
765 Concord Avenue
Cambridge, Massachusetts 02136

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Date of Report: September 25, 1985

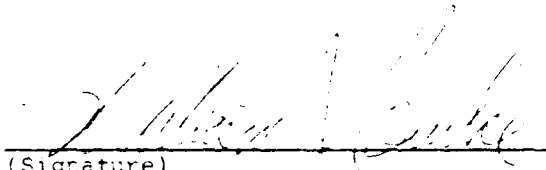
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20 July 1983 to 15 June 1985

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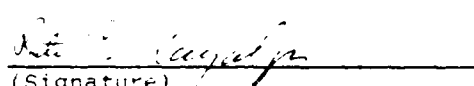
AIR FORCE GEOPHYSICS LABORATORY
AIR FORCE SYSTEMS COMMAND
UNITED STATES AIR FORCE
HANSCOM AFB, MASSACHUSETTS 01731

"This technical report has been reviewed and is approved for publication."

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(Signature)

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Branch Chief


(Signature)

RITA C. SAGALYN
Division Director

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1.0 OBJECTIVE OF CONTRACT

✓ The objective of this contract is the design, fabrication, and testing of a Spacecraft Automatic Active Discharge System (SAADS). The system will attempt to automatically control the vehicle charge as a function of natural or induced disturbances in space.

A microprocessor based controller will monitor and manipulate data from a Proton Electrostatic Analyzer (ESA) to determine if the vehicle charge is greater than a predetermined value and then activate a Plasma Source to discharge the vehicle.

2.0 INTRODUCTION

This equipment is to be flown as part of the BERT I Payload to demonstrate the feasibility of the system for eventual use in a satellite in a true space environment. It consists of a Proton Electrostatic Analyzer (ESA) (made by IRT Corporation and available to TRI-CON as Government Furnished Equipment) (GFE) and a Plasma Source made by Jet Propulsion Laboratory also supplied as GFE, plus a microprocessor based controller which is to be built by TRI-CON ASSOCIATES, INC.

3.0 CONFIGURATION

The High Resolution ESA is included in the SAADS package since it, like the IRT ESA, requires prelaunch pump-out and a blow-off door. Wentworth Institute did the design and fabrication of the extension can. The upper section has both ESA units located behind a common blow-off door. The large center section contains the JPL Plasma Source. The TRI-CON programmer box is same size as the BERT I programmer box and is on the bottom plate.

4.0 IRT ELECTROSTATIC ANALYZER MODIFICATIONS

The instrument used to detect vehicle to plasma potential is an electrostatic analyzer designed and fabricated by IRT Corporation in San Diego, California. The instrument was supplied as an eight channel device covering the range of 50 to 20,000 volts with the full width half maximum of each channel as shown in Figure 1.

During tests at AFGL the low energy channels were observed to drift with temperature to such a degree that a redesign of the plate high voltage bias circuits was necessary.

The cause of the drift was attributed to the way in which the bias voltage was derived. The IRT method for generating the bias voltage is to subtract one high voltage from another.

The problem arises when the difference voltage is in the order of 10 volts. The reference high voltage supply which is also the channeltron bias is normally set between 2500 and 3000 volts.

A 0.1% drift in the high voltage would result in a 30% drift in the resulting bias.

To improve the temperature stability, a linear high voltage feedback amplifier was designed and is shown schematically in Figure 2. The energy level for each channel was reduced to simplify the amplifier design and increase the reliability.

The maximum particle beam energy to produce vehicle charging on the BERT I payload is 4500 volts which is less than 1/4 of the original IRT range. The new design has eight channels to cover 50 volts to 10,000 volts. The new high voltage bias design has a much faster response time which results in a shorter scan and better altitude resolution.

A reprogramming of the UV erasable proms was required to generate the new incremental voltages and to minimize the dwell time between steps.

5.0 PROGRAMMER

The programmer uses the same box design as the BERT I Programmer Box. A decision to use the 6809 microprocessor means that the program card is a duplicate of the BERT I card. The memory card has been updated to give more memory by using higher density RAM chips.

The SAADS Flight Monitor Program was developed using the Zenith Z-100 microcomputer as the host computer, supplying the necessary editing, code assembly, and program downloading.

The text editor (VEDIT by Compuvision) and cross assembler (XAS:16809 by 2500 A.D. software) are generic packages and run on any microcomputer capable of running MS-DOS (Microsoft Disk Operating System). Downloading of developed programs into the SAADS programmer was accomplished with a terminal emulator program (PC/Intercomm by Mark of the Unicorn Software). This program is hardware dependent and will run only on a

Zenith Z-100 microcomputer.

Downloading programs into the SAADS programmer was done through the use of a monitor PROM (HUMBUG-09 by Starkits) with program debugging capabilities.

An algorithm to determine the vehicle charge from the IRT data was developed by Bedford Research Associates (BRA) on a separate contract. However, it was not used. Another algorithm was developed and is now burned into the flight PROM, along with the instrument program.

Using the above software, basics of the SAADS Flight Monitor were written. This include codes to:

- (1) Read data from IRT's ESA
- (2) Read the A/D converter
- (3) Read a command from the BERT Programmer
- (4) Write a command to the JPL Plasma Source
- (5) Write data into the TM Shift Registers.

A Block Diagram of the SAADS is given in Figure 3.

The memory map of data storage on the memory board of the programmer is given below.

| | |
|------|--------------------|
| 0000 | Data for Flight |
| 0090 | IRT Data and SIOS |
| 0100 | Data for D-R06 |
| 4000 | D-R06 Monitor (2K) |
| D000 | Flight Monitor |
| D200 | SIOS |
| F000 | Humbug |

A schematic of the Programmer Input/Output board is given in Figure 4.

5.1 Telemetry Format

The telemetry format is given in Figure 5.

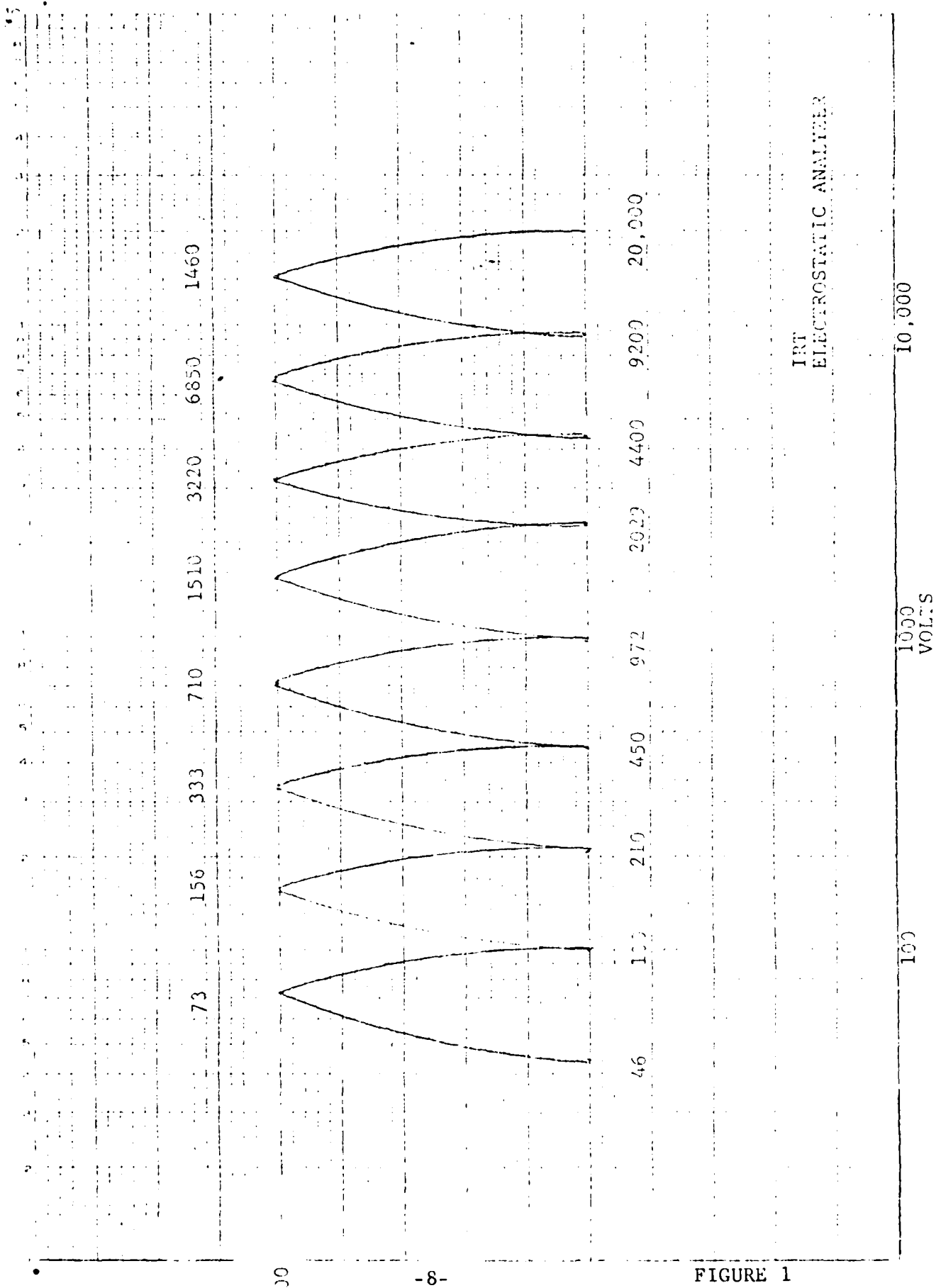
6.0 SAADS UNITS TESTED

The SAADS units were tested at AFGL. The programmer received data from the IRT Analyzer, processed it using the algorithm and was to control the JPL plasma source. However the plasma source was not available for the flight. The IRT data was put onto telemetry.

7.0 FIELD TRIP

The system was assembled as part of the BERT I Payload and shipped to White Sands Missile Range. Charles Risicato of TC assisted at the launch which took place the night of June 14, 1985.

Unfortunately, the telemetry encoder malfunctioned when the electron gun of the BERT system was energized and no good data was received.

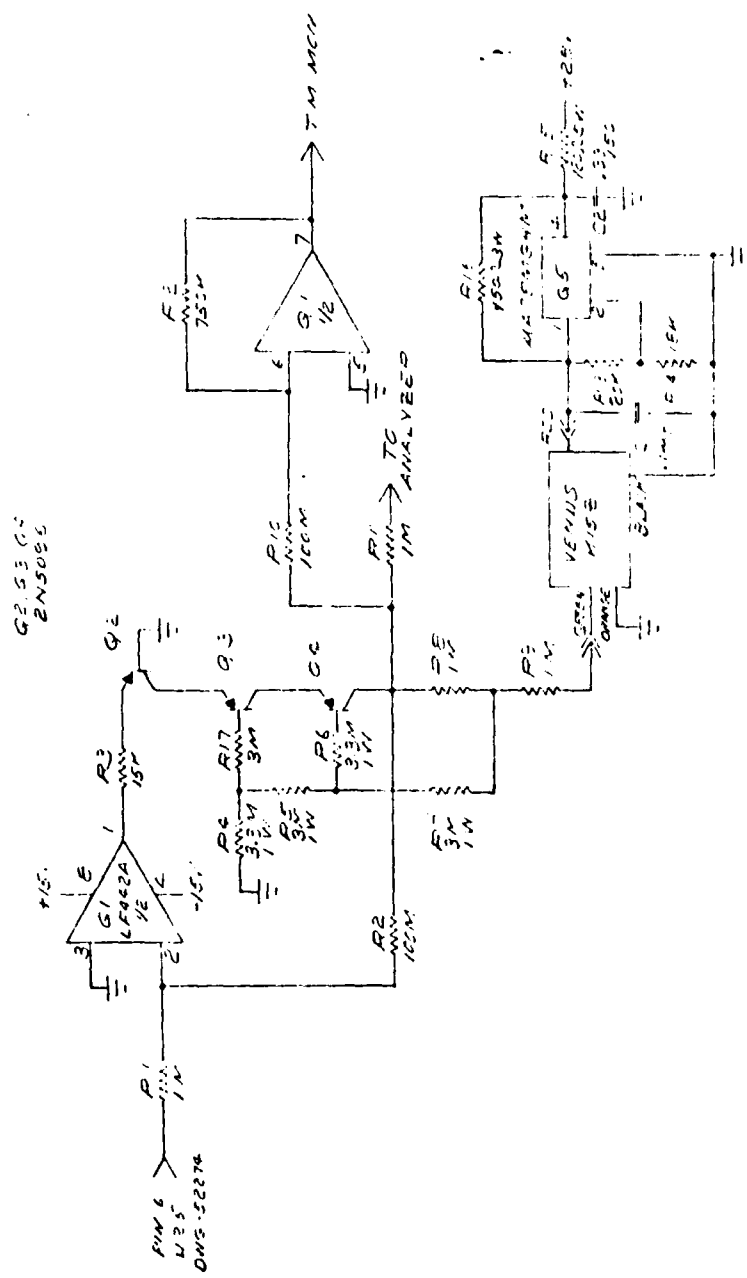


IRT
ELECTROSTATIC ANALYZER

FIGURE 1

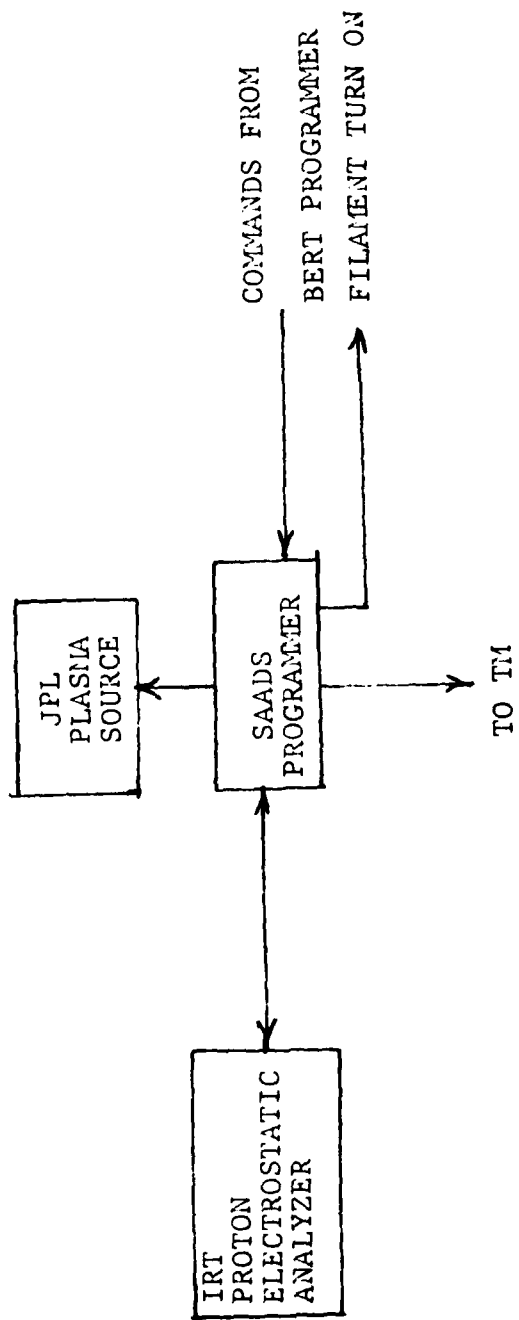
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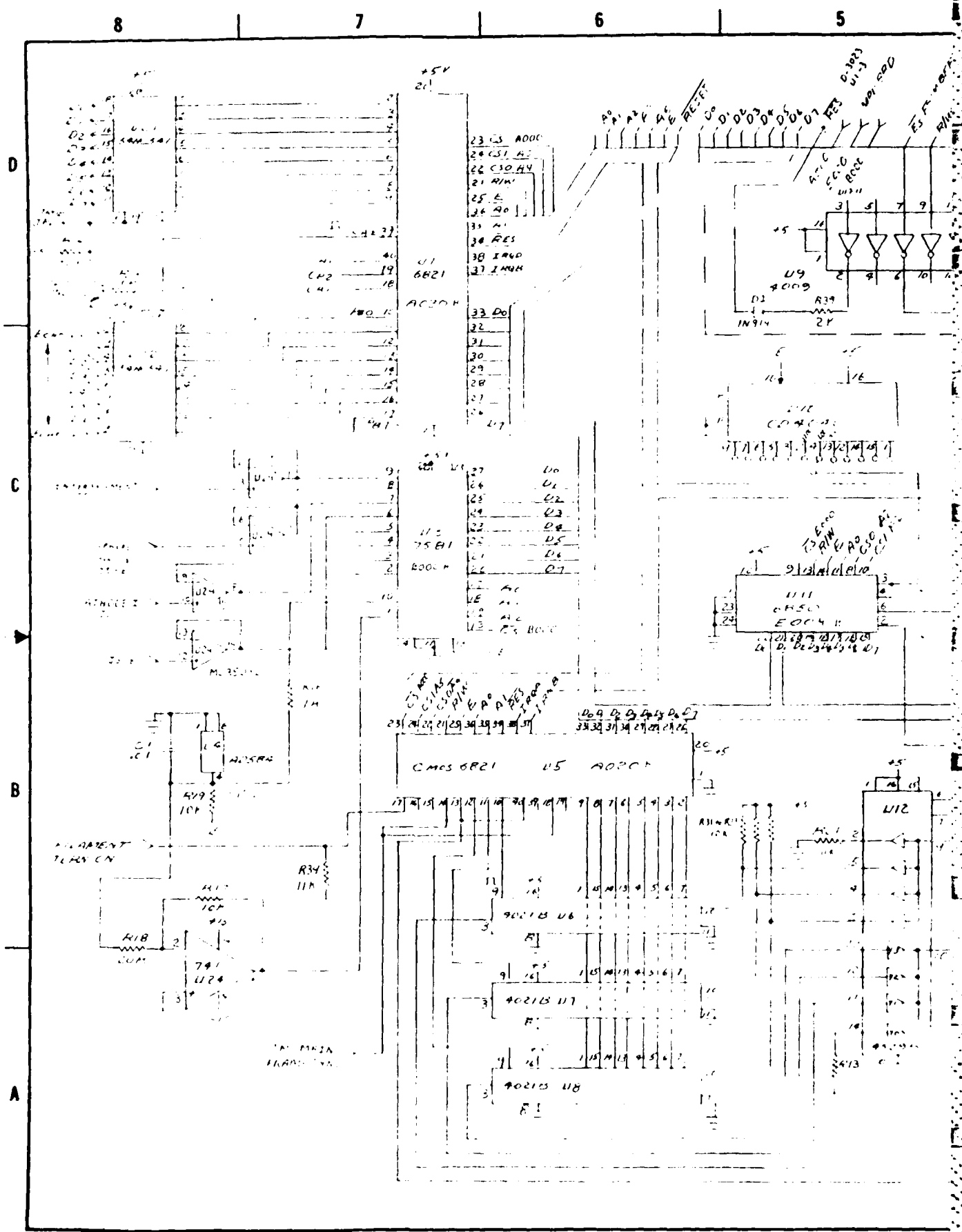
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| | | TELETYPE | | | | | | | |
| | | TELEVISION | | | | | | | |
| | | TELEGRAPH | | | | | | | |
| | | TELEPHONE | | | | | | | |
| | | TELETYPE | | | | | | | |
| | | TELEVISION | | | | | | | |
| | | TELEGRAPH | | | | | | | |
| | | TELEPHONE | | | | | | | |
| | | TELETYPE | | | | | | | |
| | | TELEVISION | | | | | | | |
| | | TELEGRAPH | | | | | | | |
| | | TELEPHONE | | | | | | | |
| | | TELETYPE | | | | | | | |

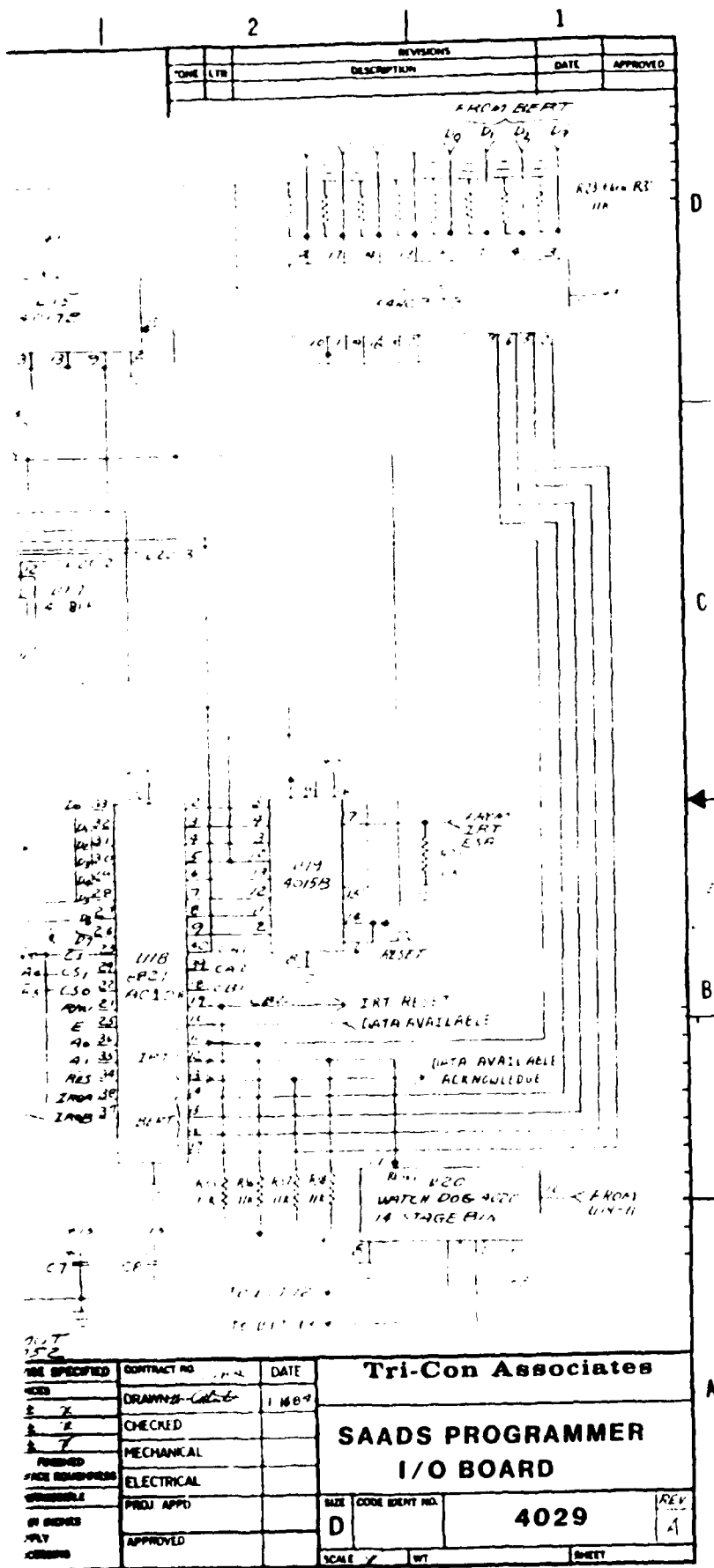


BLOCK DIAGRAM

FIGURE 3



①



| FRAME | WORD 17 | WORD 18 | WORD 19 |
|-------|-------------------------------|-------------------------------|---------------------------------|
| 1 | MSB | LSB | CHANNEL 1 IDENT 50 |
| 2 | " | " | CHANNEL 2 51 |
| 3 | " | " | CHANNEL 3 52 |
| 4 | " | " | CHANNEL 4 53 |
| 5 | " | " | CHANNEL 5 54 |
| 6 | " | " | CHANNEL 6 55 |
| 7 | " | " | CHANNEL 7 56 |
| 8 | " | " | CHANNEL 8 57 |
| 9 | CHANNEL # WITH MOST COUNTS | COMMAND FROM BERT | ALL 1's FIL ON " 0's FIL OFF |
| 10 | ISV OUTPUT | SPHERE OUTPUT ZERO AT 3.75 | JPL CATHODE I |

TELEMETRY FORMAT
FIGURE 5

END
FILMED

5-86

DTIC